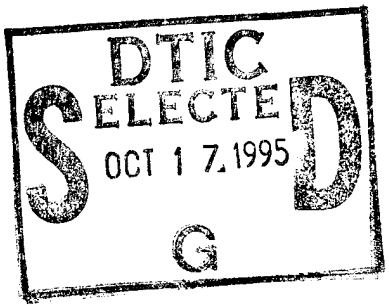
QUARTERLY REPORT FOR THE PERIOD 1/1/95 TO 3/31/95
Nanostructured Bearing Alloy Studies
[ONR N00014-94-1-0579]

SUBMITTED TO

OFFICE OF NAVAL RESEARCH
MATERIALS SCIENCE DIVISION
ARLINGTON VA

ATTN DR. L. T. KABACOFF



BY

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April 27, 1995

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April 27, 1995

Dr. L. T. Kabacoff
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Dear Larry:

Enclosed are the quarterly reports for the period Jan-March 1995. If you have any questions please call.

Best regards.

Sincerely yours,

Kenneth E. Gonsalves
Associate Professor

encl:
CC: 1) Admn. Grants Officer
ONR Representative
Draper Lab. Boston
2) Director NRL, DC
3) Defense Tech. Information Center
Alexandria, VA

C. C. Law

Quarterly Report

PROCESSING (Consolidation)

Introduction:

Work prior to this reporting period focused on achieving a more inert atmosphere for handling and consolidation of the nano-scaled steel powders. As a result, oxygen content in the nano steel powder compacts has been decreased significantly. However, even the decreased level (3% to 5%) is still too high. Further, high carbon levels (6% to 10%) which originate from the chemical synthesis of the powder, were also observed in the powder compacts. Treatment of the nano-scaled powder in a hydrogen retort would reduce the carbon and oxygen contents. Therefore, a study the effects of hydrogen treatment temperature on the interstitial contents was conducted during this reporting period. Several batches of nano-scaled powders produced by sonication reactions were hydrogen treated using the selected temperature and then consolidated in the vacuum hot press.

Results:

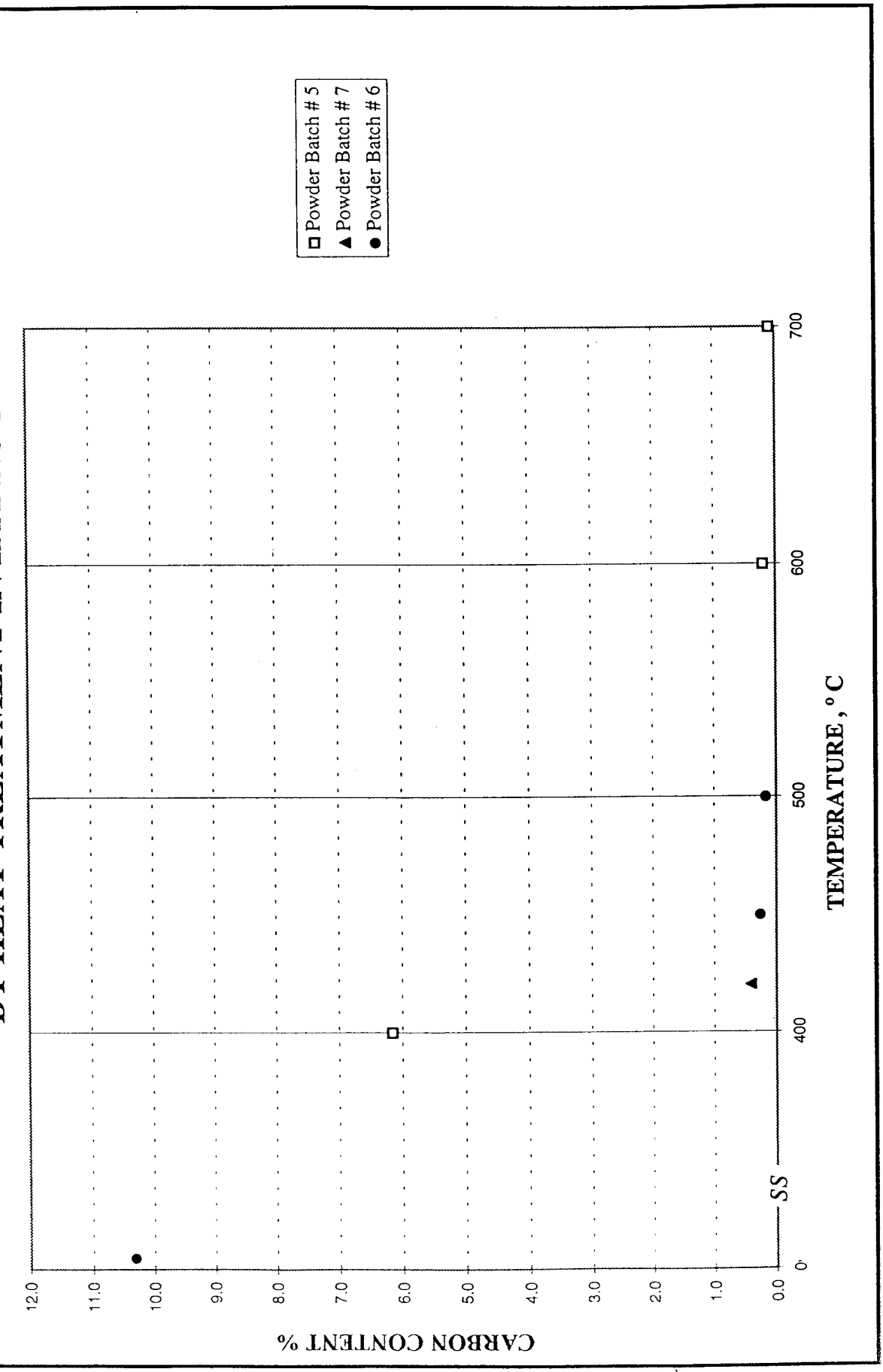
The effect of the hydrogen treatment temperature on the the carbon content is shown in Figure 1. The powder samples were treated for two hours at temperatures indicated. Figure 1 shows that the carbon levels were successfully reduced from the initial levels of 6% to 10% to less than 1% when the temperature exceeds 400C. The oxygen levels which could be determined from consolidated samples only appeared to be unaffected by the hydrogen treatment up to 800C, the highest temperature studied. The reason for the apparent oxygen stability is unclear. It could be due to the stability of the oxide or oxidation of the hydrogen-treated powder during subsequent handling for consolidation. A new approach for controlling the oxygen content by nitridation of the powder is currently being explored.

The powder consolidation was rather successful for the 5 batches of powder produced by sonication reactions during this reporting period. The interstial contents and hardness of the powder compacts are summarized in Table 1. All the powders were hydrogen treated for 2 hours at 420C and consolidated at 700C under 275 MPa. The microstructures in these compacts are being studied using x-ray diffraction analysis and TEM techniques.

TABLE 1
CHEMICAL ANALYSIS AND HARDNESS OF POWDER COMPACTS

Compact No.	7I	8J	9J	10L	11K
H%	-	0.030	0.030	0.010	0.007
C%	0.41	0.37	3.50	0.34	0.57
O%	5.40	>5.0	>5.0	>3.5	>3.5
N%	-	-	-	0.031	0.032
Hardness RC	66.3	38.0	56.0	65.5	56.5
Consolidation	Complete	Complete	Partial	Complete	Complete

Figure 1 REDUCTION OF CARBON IN NANO M50 POWDER BY HEAT TREATMENT IN HYDROGEN



John Morral,
Department of Metallurgy

Quarterly Report, Jan. - March '95

Physical Metallurgy of Nanostructured M50

B. Significant Results for the period 1/1/95-3/31/95

Physical Metallurgy of Nanostructured M50

Sample E3, a nanocrystalline M50 sample containing 6 wt% C, was used to develop experimental technique because of it's off chemistry. It was sectioned with a low speed diamond saw while still mounted in thermosetting resin in order to cut thin, 0.6 mm, sections without cracking. Samples were then heat treated in stainless steels tubes that contained argon to prevent oxidation and decarburization. Additional etching and x-ray techniques to reveal grain size and retained austenite are still being developed. They are needed for baseline studies on M50 as well as for studies on nanostructured materials.

Phase diagram calculations were made for M50 with the software Thermo-Calc. It predicts the phases present as a function of temperature and percent carbon as shown in Figure 1. In addition, it predicts phase fraction charts that give the amount of each phase present versus percent carbon at the recommended austenitizing temperature for M50 of 1125°C as in Fig. 2. Fig. 2 predicts that sample E3 with 6wt%C is nearly all cementite with some liquid present at the annealing temperature. The sample hardness of 600 -900 VHN and microstructural evidence of incipient melting support the Thermo-Calc predictions.

B. Planned work for the period 4/1/95-6/30/95

Physical Metallurgy of Nanostructured M50

The required etching and x-ray techniques will be fully developed and heat treatments will begin on the most recent batches of nanostructured M50 material, which have carbon contents below 1wt%. The samples will be heated, quenched and cold treated to determine grain growth and austenitizing kinetics as well as to characterize the martensitic transformation. The goal will be to establish the effect of nanocrystalline grain size on the hardenability, martensite microstructure, carbide distribution, retained austenite, and hardness of M50 steel.

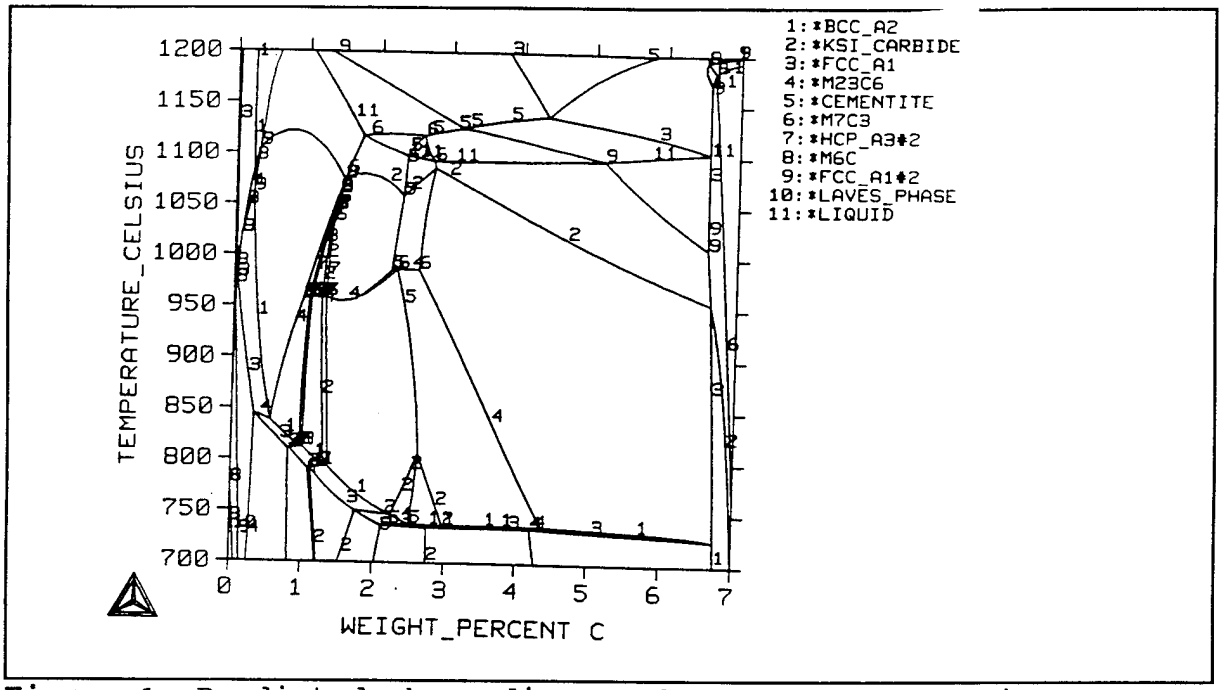


Figure 1: Predicted phase diagram for M50 as a function of temperature and wt%C. Numbered lines outline regions where a particular phase, identified in the key, is expected.

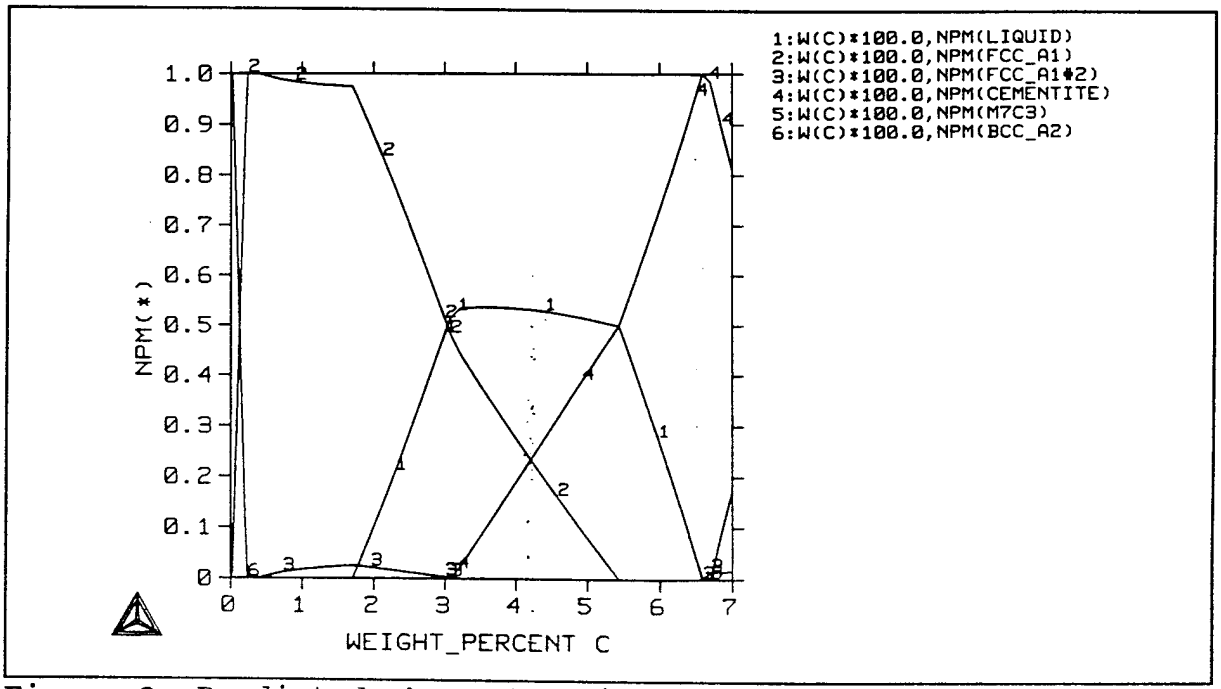


Figure 2: Predicted phase fraction chart for M50 at 1125°C. Each line gives the fraction of a phase versus wt%C.